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ABSTRACT

Because opportunities for active social roles are essential for adolescents to develop into socially responsible and competent adults, it seemed logical to devise a high school curriculum in which result-oriented investigation of real problems by the students plays a major part. To this end, a conference addressed itself to formulating the meaning of such an approach at the secondary level, planning bridges to other learning modes and to particular disciplinary studies, considering strategies suitable to work within the organizational structure of the secondary school, finding an equitable allocation of resources among disciplines, discussing undergraduate and graduate teacher training experiences, and examining potential issues in evaluation of this approach. Participants were drawn from various curriculum projects, from teacher training programs, and from the ranks of skilled teachers and supervisors. Topics covered included the following: the urgency for a problem-solving approach in education; delineation of a comprehensive problem-solving-based curriculum for secondary schools; an overview of suggestions for curriculum development; implementation and assessment; and recommendations for action by school and community groups. An appendix contains topics for a comprehensive problem-solving-based curriculum. (Author/KSM)

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DRAFT* OF

ABRIDGED** REPORT OF THE ESTES PARK CONFERENCE ON LEARNING THROUGH INVESTIGATION AND ACTION ON REAL PROBLEMS IN SECONDARY SCHOOLS

Supported by a grant from the National Science Foundation,
Materials and Instruction Development Section,
Division of Pre-College Education in Science

* The final report will include reactions from various educational and community groups.

** The full report contains more detailed suggestions for curriculum development, implementation, and assesment and additional appendices.

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INTRODUCTION

The intense curriculum development activity of the 1960's served as background for the particular goals and strategies of the Unified Science and Mathematics for Elementary Schools (USMES) project and, at the secondary level, for The Man-Made World (ECCP), The Environmental Studies Project (ESP), The Intermediate Science Curriculum Study (ISCS), the Secondary School Science Project (SSSP), and similar projects aimed at direct student involvement in interdisciplinary problem-solving.

The experience of tradition-breaking development programs, initiated in the late 1950's, had exposed many school problems related to public attitude, environment, administration, curriculum, and teacher education. At the same time, it had also given evidence of the remarkable ability of children to learn and use materials far beyond the expectations and experience of most of the adult population. The possibility thus emerged that children might be better prepared for an effective role in an increasingly complex society by a more direct, real-problem-based approach than that allowed either by traditional curricular topics or by the first wave of curriculum reform. This possibility prompted leading scholars to convene the 1967 Cambridge Conference on the Correlation of Science and Mathematics in the Schools. The recommendations of that conference are thoroughly formulated and documented in a report of the conference, Goals for the Correlation of Elementary Science and Mathematics.

This report of the 1967 Cambridge Conference states that the important objective of science and mathematics education for the population as a whole must be to increase the efficacy of individuals in making decisions which will affect their own lives in society at all levels - at the personal level, the level of trade and politics, and science and technology. This requires that students learn the process of modeling a problem, searching out facts and concepts that may be adaptable to a situation, and develop confidence in the method employed. Tackling recognizable real and practical problems, in which the students themselves can make some headway, was seen to be the way to accomplish those objectives. The practicality of the "real world" problem not only motivates the student, but also provides a criterion (Try it and see if it works.) for judging the correctness of hypotheses and conclusions - much needed in open-ended investigation where the teacher is often called upon to respond to claims or questions. The student may call on technical resources as he recognizes his need for them and still be left with wide scope to explore his own ideas and methods. Indeed, most real world problems are interdisciplinary when their various aspects are examined.

The formation of USMES was the response to the recommendations of that conference. USMES has concentrated on the elementary school curriculum for two reasons. First, the earliest learning should develop a good understanding of the problem-solving process. The students appreciation of this process will then motivate every later state of learning. Second, there is no basic organizational obstacle to introducing such an approach into the self-contained elementary classroom. The project has conceived its "challenges" as being the core of

mathematics, natural science, and social science for the elementary schools. Each challenge is long-range in nature, thus permitting the important processes of open-ended investigation to take place.

The response of students, teachers and administrators to USMES activities in their schools is indicated not only by enthusiastic reports but by the fact that more than half of the teachers in several schools spend many hours of the time allotted to science, mathematics and social science on USMES activities. This response plus the interest shown by seven universities in incorporating USMES into pre-service and in-service courses suggest that this approach may have some aspects applicable to learning in secondary schools.

In spite of the difficulties within the departmental framework of high schools, projects such as ISCS and the others mentioned above are developing units for the high school that are problem-oriented rather than discipline-oriented, particularly in the area of environmental studies. Also there is a growing emphasis on selecting for study major problems which require the use of community resources in their solution, or which elicit a useful product as the end result of the activities undertaken. Such problems often help relate a student's studies to careers or vocations. However, these materials often have been used in an additive way, rather than forming the core of a new interdisciplinary high school curriculum. Moreover, the bulk of them are case-study oriented and do not provide high school students with the opportunity actually to contribute to the solution of real world problems of recognizable value to the students or their community.

The goals of the 1967 Cambridge Conference, the role of the USMES project in elementary schools and the experience of evolving projects in secondary schools, seem applicable and important to the central concept of secondary education. In addition, opportunities for active social roles are considered by many to be essential for adolescents to develop into socially responsible and competent adults. Therefore, it seems logical and worthwhile to devise a high school curriculum in which result-oriented investigation of real problems by the students plays a major part. To this end, a conference on "The Role in High School of Interdisciplinary Learning Through Investigation and Action on Real Problems" was held at Estes Park, Colorado from January 2-14, 1973. The conference addressed itself to six tasks:

(a) to formulate and clarify the meaning of such a pedagogical approach at the secondary school level;

(b) to plan the "bridges" to other learning modes and to particular disciplinary studies;

(c) to consider what strategies are suitable and necessary to work within and improve the organizational structure of the secondary school so that it may include interdisciplinary studies;

(d) to find an acceptable solution to the problem of equitable allocation of resources (time, space, staff) among disciplines within the interdisciplinary programs;

(e) to discuss undergraduate and graduate teacher training experiences which can orient and prepare future teachers for this approach and

(f) to examine potential issues in evaluation of this approach.

Participants were drawn from recent mathematics, science, and social science curriculum projects, from ongoing interdisciplinary and action-oriented curriculu development projects, from teacher training programs, and from the ranks of skill teachers and supervisors. In addition, there were reputable scholars in specific disciplines, as well as those experimenting with interdisciplinary approaches at the college/university level. The criterion of established competence in their area of expertise, as well as the commitment to the value of learning through involvement with real and practical problems, was used in selecting persons to work on the tasks of the conference.

URGENCY FOR A PROBLEM-SOLVING APPROACH IN EDUCATION

> If there is especial need of educational reconstruction at the present time...it is because of the thoroughgoing change in social life accompanying the advance of science, the industrial revolution, and the development of democracy. Such practical changes cannot take place without demanding an educational re-formation to meet them, and without leading men to ask what ideas and ideals are implicit in these social changes, and what revisions they require of the ideas and ideals which are inherited from older and unlike cultures.
>
> --John Dewey (1)

In stable primitive societies, the accumulated culture is transmitted to each new generation through informal processes - that is, in any of the numerou ways by which learning occurs without schools. Such informal processes are supplemented here and there by rituals or ceremonies. Aside from certain secre lores reserved to chiefs, priests, or magicians, and except that males and femal might be taught different skills and attitudes, more or less the whole of the c ture is learned informally by every member of the society. More particularly, the solutions to most problems faced by the individual are contained within the culture.

By contrast, an advanced industrial society, such as our own, possesses an accumulated culture so vast that there is no possbility of, or point in, lea ing all of it. Furthermore, there is perpetual flux in the over-all content of our culture and in the interactions among its many parts. The result is a never-ending stream of problems at all levels, from trivial to global, for whic the culture provides no pre-programmed solutions. The ability to solve proble thus becomes one of the most crucial skills for members of an industrialized society.

Primitive societies incorporate their children into the adult world at, or shortly after, adolescence. In our society, a few generations ago, it was stil common for most of each new generation to assume adult roles by age 14, with many specialized skills being learnied on the job, with or without apprentice- ship. In other words, a little formal education, plus on-the-job experience, prepared early adolescents to cope with the problems of their culture. The relatively few who went on to finish high school or college entered a professio or the then relatively few white-collar jobs.

The "knowledge explosion" of recent decades has changed American culture in ways that has made it necessary for a substantial fraction of the adolescen population to complete these higher levels of formal, school-based education. As it has evolved thus far, extended formal education has had at least two un- fortunate and unanticipated effects. The first is the virtual elimination of learning-by-doing process that characterized the adolescent years of earlier t and the substitution for it of learning by reading, by watching, and by listen The second is a shift from education as a preparation for coping with problems

presented by the culture to education as a process of acquiring a prescribed body of knowlege for its own sake or because an accreditation agency deems that knowledg valuable. Our educational system has expanded quantitatively to provide the extra years of education that the complexity of our society requires. But it has done so at great cost in the loss of appreciation by students of the value and power of learning. Together, these losses have caused intense disaffection among large numbers of today's students.

The question, as the conferees see it, is how to remedy these unfortunate trends; how to provide a curriculum that re-establishes the connections between school and society, between student concerns and the curriculum, and between students and the larger community. This curriculum should not consist merely of a set of facts, or even bodies of knowledge, set out in advance to be mastered. Instead it should incorporate a body of experiences in which the real and dynamic quality of the world is represented in the classroom. Knowledge should not be acquired solely to be applied to life at some future time. Knowledge should rather be viewed as a means to identify, clarify, and seek solutions to problems that develop from real situations experienced by adolescents.

Learning does not begin in books, it begins when the student perceives inadequacies around him and feels dissatisfactions about them. The student can solve problems that the teacher raises or those posed by other students, but the intrinsic motivation is less than when he begins with his own concerns and curiosities. What is known as content can be better learned as the student seeks out sources of information, weighs evidence, and makes sense out of his attempts to solve real problems. In Whitehead's words, "Let the main ideas which are introduced into a child's education be few and important, and let them be thrown into every combination possible. The child should make them his own, and should understand their application here and now in the circumstances of his actual life". (2) In the course of such learning by problem solving the stude may also develop insights into possible ways of building a better society.

Education as Stimulation of Human Development

Education can be understood as the stimulation of human development. Adolescence is a distinct stage in the process of human growth. While there is no definitive agreement amongst psychologists as to one theory of adolescence, there is general consensus that a number of things happen in the teenager's development that have a significant influence on what he is interested in learning To the extent that educational programs recognize and are designed to facilitate these aspects of adolescent interest and development, they are likely to be that much more effective.

A first point is that adolescents are capable of adult thought. They have achieved what Piaget (3) calls "formal operations." In essence, adolescent think in ways qualitatively different from the thinking patterns of children. They can conceive of probabilities, they can think abstractly and hypothetically, their sense of time perspective changes, and they can see issues and themselves in a variety of ways both present and future. Rohwer (4) has argued that, as a result, adolescence is the <u>prime time</u> for intellectual or cognitive stimulat and education. Others estimate that only about half of American adolescents and

adults in fact achieve fully this capacity for formal thought. The main point is that adolescents possess essentially the capacity for rational and abstract thought that they will have as adults. Further, they enjoy using this new capacity. Educational experiences or curriculum can be built on a solid premise with regard to the ability and motivation of teenagers to do rational thinking.

Adolescents are, however, concerned with more than intellectual development They actively seek individuals and ideals with which to identify. Most people who write about adolescents refer to the ideological, valuing, or ethical concer of this age group. Their moral concern and sensibility may be easily subverted into rigid political ideology, into new and exotic moralities or religions, or into despair. But under this is a concern to make moral and ethical sense of their world. Kohlberg's (5) finding that people progress through stages of moral reasoning is very helpful in understanding this aspect of adolescence. Most adolescents are moving to a "conventional" ethical code in which moral valu resides in performing "good" or "right" roles and in maintaining the conventiona order and the expectancies of others. This may be reflected in a "good boy" or "good girl" orientation; for example in behavior intended to get the approva of, or to please and help others. It can also result in conformity to the stereotypes of the majority. Other adolescents have an authority and social order maintaining ethical orientation. Here, doing one's duty, showing respect for authority, and maintaining the social order is important, as is a concern for the earned approbation of others.

The issue is not so much the way in which adolescents think about, or the criteria they use in judging, ethical issues. The important point is that they are trying to create a personal moral philosophy. If this effort is not supported by the educational program the evidence is that the adolescent is unl to develop, as an adult, any more sophisticated ethical position.

Adolescence is usually portrayed as a time in which peers, other adolescen become the most influential arbiters or sources of reference for the individual Adolescents <u>are</u> tribal people. Even if society did not segregate them they probably would choose to be with one another. The reasons for this interpersonal impetus are several. First, adolescents are sexually mature. They are supposedly concerned with issues of their own sex and sexual relationships. But more is at stake for them than simply "making out." The much subtler issue of intimate interpersonal relationships with people of the same sex and especia of the opposite sex is a central preoccupation. They are beginning to struggle with human intimacy; the process of learning how to live with, relate to, and love others. So adolescents want to be together, to do things together, to socialize, to reach out, and communicate with one another. It is a time of chums, of friends and gangs, of important beginning steps away from the family to new social relationships.

Depending in some degree on social class, the world of work also affects adolescents. Work may be nothing more than a part-time job at MacDonald's as a way to achieve some financial independence of the family. Or it can be an imminent issue for students going into the armed services or into apprentice training at the end of high school. For many adolescents, those who are colleg bound, the issue is rather what college than what job. For them, career decisi are deferred until the end of college or perhaps longer. But work, as one more attribute of what it is to be adult, impinges on the adolescent.

It is almost a cliché in discussions of adolescence to talk about this period in terms of "identity formation." Erikson (6) has stated that the central problem the teenager faces is to define himself - to create a sense of his own identity. This argument will not be elaborated here. Essentially, adolescents are struggling to form more comprehensive answers to the question "Who am I?" Their new intellectual capabilities are applied to that question: Ethically they are trying to answer it; so too, in the development of new competencies and in the context of their relationships with peers. Whether or not education chooses to respond to this question, developmentally, it is a central one.

What is often not said about adolescents is that they can be remarkably competent people. Adolescents can learn to teach or counsel other people as effectively as graduate students or practicing professionals. They can carry out sophisticated programs of social research and action. They can learn to fly airplanes and military aircraft. They can produce musicals, conduct complicated scientific experiments, and write subtle poetry. Extensive opportunities to do these things are essential if adolescents are to develop into competent adults. There is much psychological and educational evidence to support this. Adolescents need opportunities to take active social roles, to have significant and systematic responsibility for analysis and action on real problems, and to be held accountable. It follows that comprehensive problem solving should be an integral part of the educational system.

In summary, physical development is completed in adolescence. Sexual maturit is achieved. Adult intellectual capacity is reached. Idealism is strong. Family influence wanes and is supplanted by that of contemporaries. Economic independenc is possible. So, too, are many adult competencies. The rites of passage (a driver's license, leaving school, legal drinking, voting, being drafted, etc.) are available or within view. Obviously no longer a child, the adolescent is not quit an adult. Education best serves the adolescent if it actively supports him in the "in-between" world of becoming.

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DELINEATING A COMPREHENSIVE PROBLEM-SOLVING-BASED CURRICULUM FOR SECONDARY SCHOOLS

> Thus although schooling remains a small portion of education, it occupies an increasingly larger portion of a young person's time, while the remaining portion of his education is not well provided by ordinary, everyday, unplanned activities. Consequently, if an appropriate reform of education is to be made, it must begin with this fact: school is not all of education, and the other parts of education require just as much explicit planning and organization as does schooling.
>
> - James S. Coleman (1)

Considerations such as those delineated in the previous chapter led conferee participants to consider a problem-solving approach as a curriculum vehicle to integrate disciplines, school and society, and the lives of students.

The principle premise upon which to base a new curriculum might be that the essential purpose of education is the stimulation of the individual's development. That is to say, an education for adolescents must stimulate cognitive or intellectual growth, social and intellectual competencies, emergence of identity, moral sensitivity and reasoning, vocational pursuits, aesthet development, and physical fitness. The challenge is to provide the needed formal education while developing the students' awareness of its importance and, concurrently, involving them with the needs and goals of themselves and their society. The response to that challenge must serve youth of all social backgrounds and all aspirations: personal, vocational and intellectual. Although much of the present secondary school curriculum addresses these goals, the approa is made in a vacuum. There is an absence of real-problem experiences that provide adolescents with comprehensive, cross-disciplinary, utilitarian challenge and that allow them to feel empowered, useful and efficacious. A comprehensive problem-solving-based curriculum in the secondary school is one means to this end. It was on this approach to curriculum that the conference focused its efforts.

Model for Comprehensive Problem-Solving

A comprehensive problem-solving-based curriculum is one in which students can become deeply involved in solving problems that are real to them and can put their solutions into action. The scope of such problems might encompass the classroom, school, or the larger community. Students can not only become involved in a broad range of disciplines, with the guidance of a number of subject matter specialists, but also have the opportunity to follow a problem from its original statement through to the implementation of their solution, whe feasible. Inherent in the nature of this approach is the way in which problems are attacked and solved, namely, an understanding of the issues is of paramount importance before the answers are attempted. Students should be familiar with, and understand the limitations of, scientific methods of inquiry.

In the model offered here, "comprehensive" refers to three aspects of problem solving: the scope of the problem; the range of operations in the problem-solving processes; and the inherent appeal of dealing with life situations as wholes.

Comprehensive problems have many facets that cut across and blur disciplinary lines and require for their solutions a wide range of operations including analytical and synthetic processes. The relationship between scope and range of operations can be diagrammed as in Figure 1.

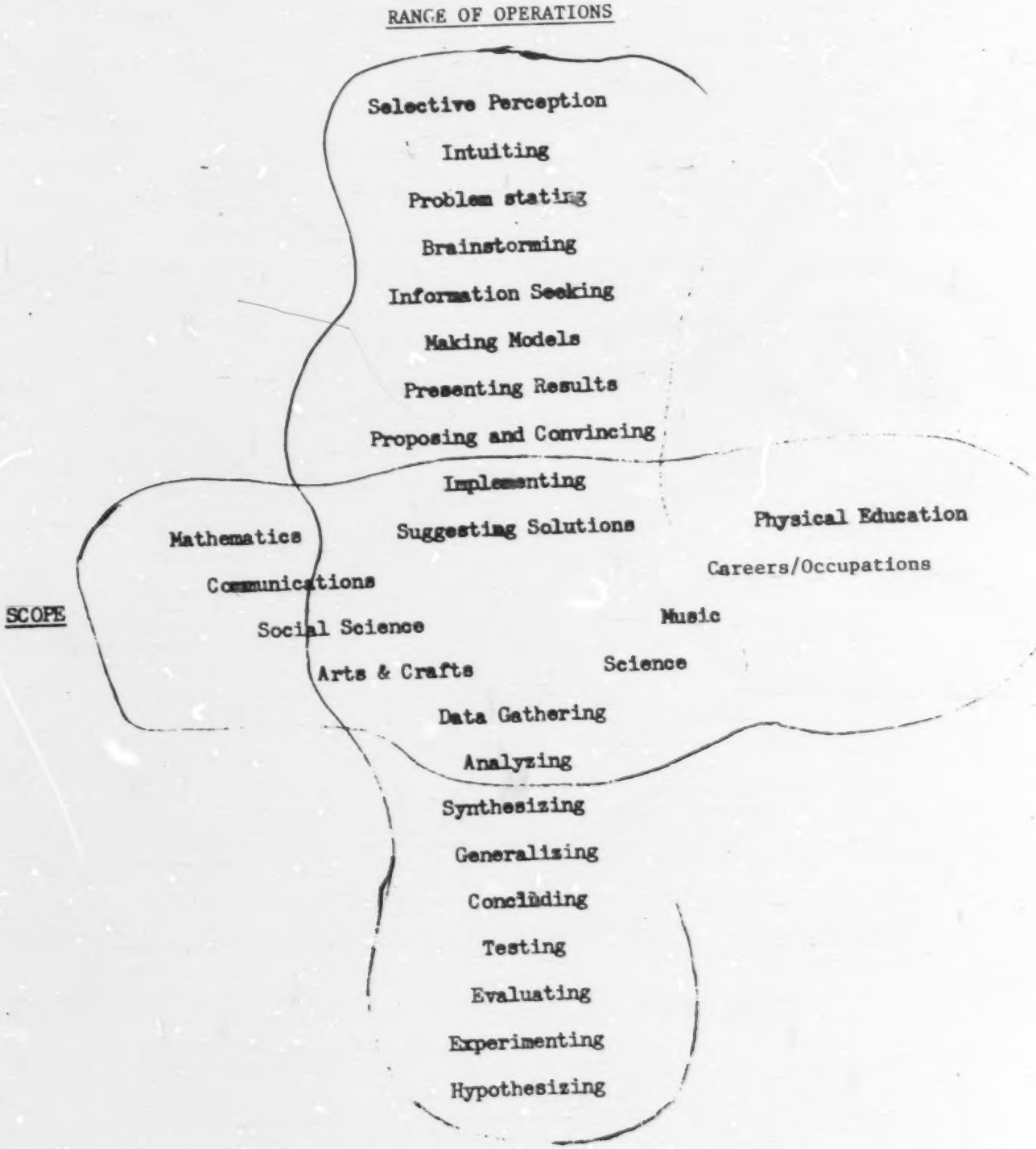


Figure 1

When people deal with problems that emerge from their own experiences, the problem as understood connects both backward (past experience) and forward (future consequences of actions taken) and, thus, is integrated with the ebb and flow of life. Even though suspended judgment allows for experiment and reason to play roles in problem solving, the goal of solving a problem is powerful motivation only when the solution has meaning and leads to action and consequence. Thus the third aspect of problem solving is comprehensive in its pervasive appeal and in the depth of involvement.

Two crucial and related aspects of the model are the criteria by which students (with the support and encouragement of teachers) select problems and the probable sources of problems. To optimize the motivation and the opportunities for learning, a problem should have most of the following properties appealing to adolescents and their teachers; comprehensive; at least partially solvable by nonexperts; attackable without great expense for equipment and materials; attackable by students with a wide variety of abilities and skills; capable of implementable solutions; and capable of yielding tangible products or results. Since problems that lack some of these characteristics may still serve some valuable educational purposes for some students, perhaps the most important single criterion is that the problem be real to the student. If it is, it will promote investigation and analysis and provide a valuable learning experience, even if a narrow one.

One way to look at real problems so as to see the interconnectedness of events and phenomena (and people) is to use a circle on which are located several broad issues with overlapping implications. As a device, it enables one to move away from the particular and into the broader abstraction one must make in order to form workable generalizations to test against a particular reality. A list of issues could be: quality of life; limits of growth; values and ethics; survival; social power; cost benefit; and energy.

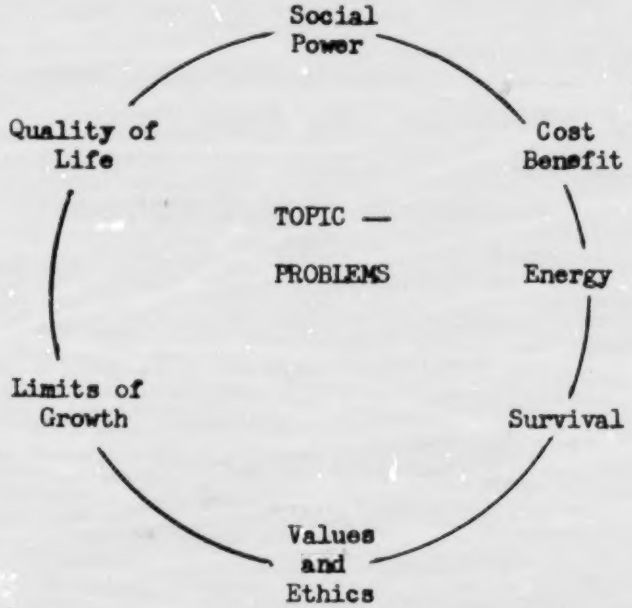


Figure 2

Each of these issues is really a rubric subsuming a host of other issues or "handles". "Social Power" speaks to the individual and to how the problem effects ego, freedom, and minority concerns. Who controls "Social Power"? Who makes critical decisions? Where can I cut into the power structure? It looks at elections, at government, at the judiciary processes, at law enforcement, at business, and at medicine, for example.

"Quality of Life" asks questions about progress and the worth of it as an absolute goal. What is progress? What are some of the trade-offs we make in pursuit of it? Although separate in the model "survival" could also be included here.

"Limits of Growth" has to do with exhausting present natural resources, with population limits, with environmental controls and protections - and, of course, with quality of life and with social power.

"Ethics and Values" relates to the content in "Tragedy of the Commons," a paper written by Dr. Garrett Hardin and published in the December 13, 1968 issue of Science, which speaks to man's values and ethics, the need for shared morality and common sense, and planning.

"Survival" points to the survival of all species, and of course, of man, too.

"Energy" has to do with resources, survival, power, problems of atomic power plants and pollution, and of geothermal and solar energy.

"Cost/Benefit" implies that all benefits have a price that must be considered.

All the issues are on the same circle and all overlap. Each can be a way into a particular reality which students can explore and which can help them perceive the greater picture while focusing on an immediately observable and measurable one. The latter, in the center of the circle, is a topic. The areas from which topics could come are:

School related experiences and needs
Environmental quality
Urban/suburban/rural social conditions
Family/community issues
Vocational/occupational interest
Cultural pluralism and ethnic relations
Individual consumer economic needs
Transportation systems
Political behavior and action
Alternative futures
Assessment of technology
Leisure time areas
Resource management (material, human, energy)
Communications and information retrieval
Population
Aesthetics
Ethics
Human sexuality
Crime (definition, detection, prevention, and punishment)
Addictions and obsessions
Individual and community health

An example of a topic that calls for inputs from many of the major disciplines presently taught in schools might be called "The Energy Crisis." In any real situation there would be local starting places for a study.

The topic could be raised by students as a result of a news item such as:

1. Twenty Denver schools close because of lack of fuel.
2. Government appeals to 50 states to conserve fuel.
3. Western AMF tool division closes permanently because of fuel shortage.
4. Gulf runs a two page advertisement saying that the short-term future for energy production looks very bad, but "we'll take care of you in the long run; trust us."
5. Colorado governor protests plans for nuclear blast to explore for oil on west slope of Rockies, since it would interfere with shale oil fields.
6. Texaco plans to put oil wells off the coast of Oregon.
7. The US Circuit Court of Appeals blocks construction of oil pipeline in Alaska.
8. The President of the United States has decided to take import quotas off petroleum imported from Canada.
9. The Canadian government is limiting petroleum exports to the United States.

One problem students might consider is "What is the energy crisis, how does it affect me and how can I affect it?" They could explore freely both inside the school and in the community to answer such questions as: "Why do we have it?"; "Will it affect us here?" They might interview business people, school custodians, public utilities employees, and municipal officials. They could find out what fuels and how much of them are found in the community. Two secondary sources that might prove useful after students have worked on their own investigations are the BSCS film Energy and the Scientific American issue on energy.

After general information is shared with the class, students could be asked to examine the uses of energy in their own homes. They could work in teams of 3 to 5 on questions such as:

What do we use that is energy?

How much energy do we use?

What does it cost?

What are our direct energy users?

What possessions do we have that took energy to produce?

What is the total direct cost of energy in my home?...the per capita cost?...the total cost in my community?...in the United States?

What can I do to decrease energy consumption?

What would happen if we decreased our energy consumption by 10% per family?

How much fuel oil (or natural gas) would we have to expend to support every person in the world at our level in the United States? (Note: Student's projection for the United States is likely to be one fifth of the actual national total because of the energy used by manufacturing and businesses outside the home.)

What is it that produces our high standard of living?

What if the oil nations quit selling oil to the United States?

What is the relationship between energy production, consumption, and environmental degradation?

Questions such as these can take students and teachers in many directions and result in various recommendations, such as reduction of fuel consumption in school or at home, or a change in the type of fuel used. In their investigation, they could decide to explore the history of man's use of energy; the nature of energy; the fuels we produce; the economics of fuel production; a redesign of their community's needs; human energy; alternative sources of energy, such as solar energy or hydrogen; the physics of heat, light, and other forms of energy; the sources of commercial energy; the political control of energy; the relationship between man-produced energy and living standards; and so on.

Each teacher or group of teachers can be expected to work differently, and each student will approach the topic from his own interests and concerns.

Included in the appendix of this report are additional topics that could serve as starting points for branching investigations determined by local concerns, student concerns, teacher interest, and special needs.

The problem-solving model consists essentially of a study of a complex problem by groups of students supported by teachers with diverse disciplinary backgrounds. The groups explore various aspects of the problem in order to understand it, and to develop and evaluate alternative solutions. In the course of this exploration, it may be necessary for students to conduct experiments, develop mathematical techniques, acquire additional knowledge from the domains of traditional disciplines, and to evaluate ethical and moral aspects of the problem. These pursuits may require them to organize and participate in group activities, consult with teachers and local experts, as well as use local libraries and other community resources. In implementing their conclusions, the students may interact with many individuals and social organizations, some of which will be proponents and collaborators, while others will act as opponents and detractors.

In outline form an approach to problem solving might be as follows:

1. Exploration of topic areas
2. Broad discussion of selected problem
3. Definition of the specific problem-solving goal
4. Listing of perceived aspects of the problem
5. Data gathering for perceived aspects
6. Analysis of data (with repetition of steps 4 and 5 as required)
7. Evaluation of data analysis to determine feasibility of solutions
8. Development of proposed solutions
9. Analysis of proposed solutions (with repetition of step 8 as required)
10. Review of practical feasibility of solution (with repetition of steps 8 and 9 as required.)
11. Documentation of proposed action

The actual problem-solving process embodies a flexible series of operations as shown in Figure 3.

It is important to recognize that, although the approach and denouement are relatively fixed steps in the process of solving problems, the main mode of attack (the large rectangle in the diagram) should be thought of as consisting of numerous linkages among many operations. All are legitimate subprocesses that can contribute to valid solutions. Some of these subprocesses are broken out in Figure 4.

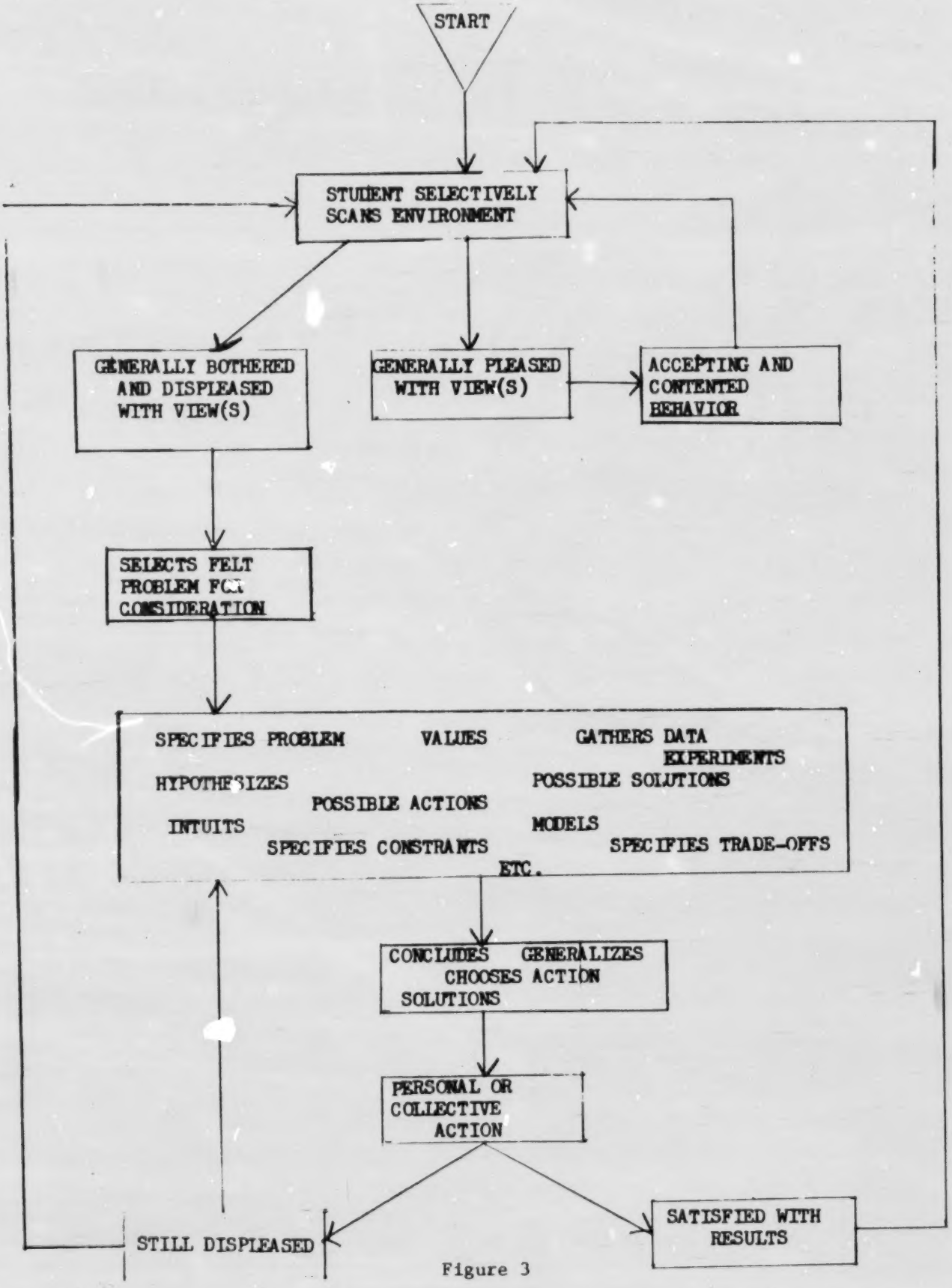

START
STUDENT SELECTIVELY SCANS ENVIRONMENT
GENERALLY BOTHERED AND DISPLEASED WITH VIEW(S)
GENERALLY PLEASED WITH VIEW(S)
ACCEPTING AND CONTENTED BEHAVIOR
SELECTS FELT PROBLEM FOR CONSIDERATION
SPECIFIES PROBLEM
VALUES
GATHERS DATA
EXPERIMENTS
HYPOTHESIZES
POSSIBLE SOLUTIONS
POSSIBLE ACTIONS
INTUITS
MODELS
SPECIFIES CONSTRAINTS
SPECIFIES TRADE-OFFS
ETC.
CONCLUDES
GENERALIZES
CHOOSES ACTION SOLUTIONS
PERSONAL OR COLLECTIVE ACTION
STILL DISPLEASED
SATISFIED WITH RESULTS

Figure 3

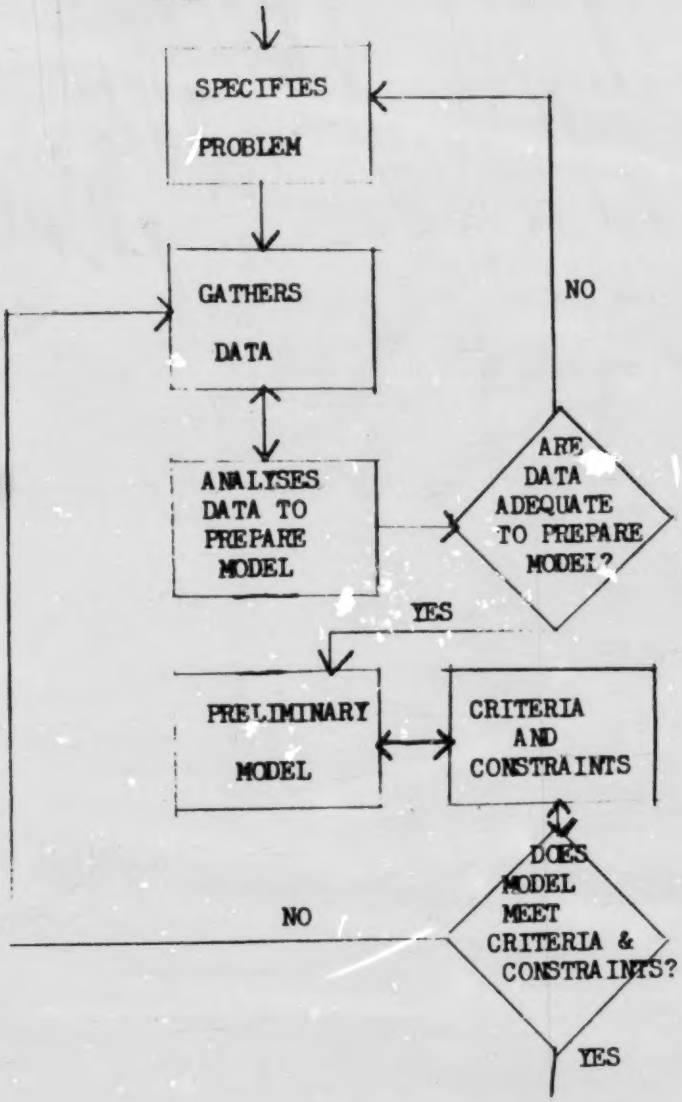

SPECIFIES
PROBLEM
GATHERS
DATA
ANALYSES
DATA TO
PREPARE
MODEL
ARE
DATA
ADEQUATE
TO PREPARE
MODEL?
NO
YES
PRELIMINARY
MODEL
CRITERIA
AND
CONSTRAINTS
DOES
MODEL
MEET
CRITERIA &
CONSTRAINTS?
NO
YES

Figure 4

In general, the conferees feel that problems selected as learning experiences should keep each student challenged to the edge of his intellectual capabilities without overwhelming him. Problems must move an adolescent to more sophisticated ways of thought, so as to arrive at more thorough analyses and more adequate responses to the problem. Problems should be relevant to the world impinging on the student as an individual and as a member of his society. The student should be able to do something with the knowledge and information gained, or at least be fully aware of the potential usefulness of a particular piece of information. Some problems should be specifically selected to develop in students the ability to see and rationally judge the ramifications of complex moral issues. This is especially pertinent since one characteristic of adolescence is the emergence of abilities to deal with abstractions and abstract thought.

Problem-solving efforts can be beneficial learning experiences for students, whether or not the efforts seem to adult society to be immediately productive or effective. This has been said another way by Abraham Maslow (2), "What needs doing, is worth doing even though not very well." It should be emphasized, however, that there are special educational advantages to problems that are real to students and have practical short-range outcomes for humans and society. Such problems are apt to interest more students for a longer period of sustained effort. They provide a bridge from the student and school to the adult and working world. They develop all problem-solving aspects in proper relation to each other, from particularization of the problem to effective implementation. They are self-checking and self-evaluating through observation of their practical outcomes, and hence do not require that a teacher know everything accurately in order to judge student performance.

To argue that useful learning can take place through problem solving in no way precludes or downgrades learning by other techniques. There are many kinds of learning - in mathematics, aesthetics, physics, economics - that cannot be understood very well without some background in the concepts and rationale of related parts of the discipline. For many students the most effective way to learn such concepts may be the relatively traditional one of exploring the discipline in a logically ordered sequence. Also, one must often accept and utilize, largely on faith and without question, many concepts and pieces of information from disciplines that are, for the moment, beyond reach.

In summary, the conference participants arrived by consensus at the following positions:

1. Most important in terms of the long-range goals of education are the convictions that through working on real and relevant problems students can learn the skills and processes necessary to be effective problem solvers, and also develop confidence in the power of knowledge and reasoning. It is a deeply held belief of many, including the conference participants, that such learned attitudes, skills, and beliefs are the necessary ingredients in developing the ability to cope with problems presented by the culture.

2. Conferees agree on several assertions about the nature of what they call a comprehensive problem-solving approach to education. The most general

assertion is that although the academic disciplines may remain intact and may frequently be explored in conventional ways, there should also be a significant portion of the secondary school curriculum allocated to a problem-solving approach that allows students to deal with and act on real problems both in the school and the communnity. These should be real problems that lend themselves to at least a partial solution. Problem-solving activities may call upon teaching resources and talents drawn from several tradtional discipline areas simultaneously and do not obviate the need for specialists in the various discipline areas. However, these specialists should be able to relate their particular expertise to other discipline areas.

3. The conference does not intend to recommend what ought or ought not be taught in schools. It nevertheless is clear that many of today's students are not motivated to learn much traditional course material because they see no use for it. Our present educational system cannot always justify its instructional content. Both it and its students stand to gain by being open to unstructured learning, which can move in directions that are controlled little or not at all by the system. In fact, an unstructured approach may often result in the learning of useful things that are not as yet incorporated anywhere in our cultural heritage, and hence could not be learned at all by formal processes.

4. By virtue of personality, interests, or background, a significant fraction of those students currently in our public secondary schools cannot or will not profit from an education that is wholly discipline oriented, and their presence in school wastes their time and the resources expended on them and seriously inhibits the learning of others. Our students and schools are desperately in need of new learning experiences that are more interdisciplinary, problem oriented, and real-world connected, and that appeal to students. The conferees believe that there is an unquestioned need for prompt addition of reasonable new modes of learning activities that are self-guided and self-motivated, and in which neither the process nor the product of learning are structured in advance by the teacher or the school.

The conferees are not so naive that they expect this approach to be completely implementable in most existing schools staffed with conventional teachers. For this reason plans for restructuring schools and suggestions for pre-service and in-service education programs for teachers are included in this report. Without these two elements, no new approach to education - however well conceived, however worthwhile - can succeed.

References

(1) Coleman, James S., "How Do the Young Become Adults," Phi Delta Kappan, Vol. LIV, No. 4, December 1972, and Review of Education Research, Vol. 42, No. 4.

(2) Maslow, Abraham H., The Psychology of Science, New York, Harper & Row, 1966.

OVERVIEW OF SUGGESTIONS FOR CURRICULUM DEVELOPMENT, IMPLEMENTATION, AND ASSESSMENT

Problems, often contrived, are used in education as vehicles for learning the content in some discipline. In a problem-solving approach to education, the content of the disciplines is used in seeking solutions to real problems. Solving real problems meets the challenge of our complex culture while at the same time keeps students in touch with reality to a degree that at least roughly approximates their joining the adult work society at an early age - as has been the case through most of human history.

With few exceptions real problems are interdisciplinary and "We must stop acting as though nature were organized into disciplines in the same way universities are." (1) Much new and quite adequate curriculum material has been developed in recent decades, and while some of it is intended to be interdisciplinary, it is usually taught within a single course or discipline. By contrast the emphasis in a problem-solving approach to education is on the process used in solving problems rather than on content. These processes are similar, if not identical, across the disciplines. The processes can be replicated and can be taught to teachers. The content a problem-solving approach cannot be specified beforehand but depends on the problem and group of students. When solving problems teacher and student learn together using the teacher's broader experience and expertise to help the student find answers to his own questions. This learning process involves the student with the ways of the normal adult world where knowledge is used to solve problems, and where problems are generally not solved in order to acquire knowledge.

Much that is learned is acquired slowly, usually after many experiences, and at a pace very different from that of teaching. When a person learns something for himself there is often a long struggle in coming to a new insight through a process of forming ideas, confronting the ideas with evidence, finding the ideas inadequate, and then trying to restructure the ideas. Unlike much knowledge acquired through formal learning, which often leaves little trace after only a few weeks, concepts painfully molded and remolded for oneself tend to become deeply imbedded in one's thoughts and feelings. Thus, even if the acquisition of concepts by a problem-solving approach sometimes seems relatively slow, the overall result may be far more efficient because of of higher retention.

For the teacher, knowledge in content areas is essential. But perhaps even more important is complete honesty, and the willingness of the teacher to be helpful when he can and to admit his ignorance and limitations when he cannot. The student will more likely acquire a positive self-image if he is not always at an intellectual disadvantage with his teacher. Also, it is important for teachers to respond to students as whole persons, rather than as fragments of persons that show up daily for class.

Experiences that result in understanding and respect for the processes involved in problem solving learning are essential for the various roles the teacher assumes. As a coordinator, the teacher deals with problems from a broad perspective in helping students determine the nature of the problem on

which they have chosen to work. At the same time, with a different group of students, the teacher may be acting as a resource person providing background knowledge and direction from his area of expertise.

The school, teacher, student, and community should become partners in problem solving. If teachers in various specialities act as coordinators and resource persons, students can work in relatively small groups in laboratories, shops, libraries, and media labs, and with community experts. Students can explore the physical, biological, social, political, economic, ethical, and moral aspects of a problem through discussion, experiment, and the use of mathematical techniques as needed and appropriate. An understanding of the scientific, technological, and social issues involved in solving a problem is important for learning, and students should become familiar with both the uses and the limitations of scientific inquiry. Students should formulate proposed solutions to their problems, and where possible seek to implement solutions. Actual or planned implementation would serve as a check on the feasibility of the solutions.

Student progress in a problem-solving approach should be assessed and reported in its own terms. That is, it should not be converted into credits in science, social studies, or shop. Instead it should be described in the student's records in terms of the projects undertaken by him, materials collected, reports written, experiences encountered, and skills and understandings achieved. The report should specifically describe the degree of skill in sizing up, gathering data for, and analyzing a problem of some complexity. In group work, the ability to provide leadership or follow where appropriate should also be reported. Evaluation by peers could be part of the assessment and students should be encouraged to engage in self-evaluation and to keep records of their actions and learning.

Structure and Support Models

A problem-solving approach to education does not depend on new facilities, equipment, or services, though some changes might be helpful. It depends much more on changes in attitudes, teacher and student schedules, uses of existing space, and transportation schedules and routes. The emphasis needs to be on flexibility and interaction with the larger community. Contracts with community agencies, businesses, or individuals could provide for additional space, services, or transportation as needed. Permission for the use of shops, laboratories, art rooms, greenhouses, and other facilities by some students not enrolled in courses that utilize them should be extended.

In a comprehensive problem-solving environment the main facility is the school resource center. Depending on the nature and content of the program, this might contain shop and laboratory equipment, dark room, audio and video taping equipment, cameras, typewriters, access to a computer, and a library with filmstrips, tapes and cassettes, resource materials, sample problems and procedures, and a file containing the reports of problem-solving activities undertaken by members of the school community. Work spaces and telephones should be located near the resource center.

Except in its most limited forms, success of a problem-solving approach presupposes strong, active support and cooperation by the principal and other administrators on whom he depends. He must gain acceptance and support by

the outside community, agree to rearrangements of space and equipment, get teachers to accept any student into their shops or studios, provide the needed transportation, allow access by students to records relevant to the problem on which they are working, and respond to the inevitable calls from parents and members of the community as some students delve into the realities of school and community life.

Nine different models for including problem-solving activities in schools are delineated in the full report of the conference. The simplest is to include problem-solving activities as a choice in the school's activity period. There problem solving can be given with or without credit, by teachers who are inclined to take part, and requires no change in schedule. At the other end of the spectrum, there is a model that coordinates part of a city school system. Here one of three schools might be converted into the resource center, while the other two continued to give conventional courses. At any one time one third of the combined student bodies would be in, or working out of, the resource center, while the other two-thirds were taking regular courses in the other two schools. Time would be allocated in half-day blocks, with students moving between schools at lunch time . Assuming that students are transported before and after school in any event, and that about two thirds of all students take the problem-solving program, this arrangement would increase the transportation load by not more than 30 percent. The increase in cost could be proportionately much less, since inter-school transportation at lunch time would involve fewer routes, have no intermediate stops, and use buses that would otherwise be idle at that time. A very large school might convert a fraction of its building, or complex of buildings, in which case there would be no increase in transportation.

To accommodate the large number of small groups involved in problem solving, some rooms in the school (or section) devoted to a problem-solving program would probably need to be divided to provide the number of rooms required. However, the number of teachers need not be increased proportionately, if at all, since many students would either be working without immediate supervision, or be off the premises. Also, paraprofessionals and student teachers could do much of the detailed supervision and older students might assist younger ones, in another form of problem solving.

Some Probable Social Effects of a Problem-Solving Program

Because actual use of problem-solving activities is not yet widespread enough to have produced substantial effects on the communities in which it occurs, the nature of such effects must be essentially speculative at this point. Because problem solving focuses student attention energetically on various social problems, it would seem likely to have social consequences. A study of such effects could, in fact, be the subject for a student problem, and it is one of the strengths of this kind of education that its process can become part of the subject matter of the curriculum, and therefore become perpetually self-evaluating.

Some social changes can be expected to occur within the school itself, particularly a closer personal relation between student and teacher, which could be evidenced by a growth of mutual understanding and respect, and with the disappearance of "teacher infallibility." As students who have completed projects become resource persons for other students, peer culture should become the support, not the enemy, of learning.

Parent-student relationships would ideally improve, as communication increased and parents were able to help their children solve problems in terms that the adult uses in his world. As with any change in relationships, problem solving will also create initial tensions, particularly where these activities are construed as students prying into adult affairs.

If a problem-solving program is taken seriously it should contribute toward the solution of some actual community problems, possibly providing free manpower for certain investigations. In some cases it should increase surveillance of possible violations of laws, and make community groups more conscious of the social consequences of their behaviors. Changes in higher education might follow as students thus educated in the public schools move on to college.

It is hard to predict exactly where a problem-solving program might lead. Its impact will be both transitional and long range. If in the transitional stage parents or members of the business, school, or larger community feel threatened by the attention received from students, it is crucial that the program be continued long enough for them to experience benefits to themselves, as well as to students. Before the advent of extended formal schooling the whole community provided the education for teenagers when they entered it as young participants. A problem-solving program seeks a new institutional arrangement that will break the subsequent isolation of education by once again making the whole community the learning ground for the young.

Curriculum Development and Teacher Education

Although scattered groups of teachers can use problem-solving activities, their widespread use requires new patterns of pre-service and in-service education. Since teachers tend to teach as they have been taught, teacher education must utilize the same processes that teachers are to use with students.

The curriculum for a school should be developed by the teachers, administrators, and students in that school and not by a distant team of experts. If experts are brought in to help develop the curriculum, they should play the same role for the teachers that teachers play for students - they should help the teachers help themselves. It might be useful for teachers with their principal(s) to meet for several weeks at a site removed from immediate administrative and teaching pressures where the processes used in solving problems could be explored. Problem topics could be listed and steps in the process of finding solutions to those problems could be formulated and tested. But the problems thus listed should not be later imposed on students, who should instead be allowed and encouraged to select problems that bother them. It is the relevance of the problem to the student, not the teacher's concept of what ought to be learned, that should determine what will be studied. Even the process should be determined only in a broad way in the course of curriculum development. Its details should always be modified for the particular problem, students, and circumstances.

In recent years problem-oriented interdisciplinary courses have been introduced into many liberal arts colleges, and a variety of honors courses now put many students into self-guided but supervised study of particular problems. Without ceasing to study disciplines (since each teacher will be a consultant and possibly a teacher in a discipline, as well as an advisor to his students) the pre-service teacher should get experience in problem-oriented courses, and colleges should be encouraged to make more of them available.

Academic professors who teach pre-service teachers should be encouraged to teach problem solving in schools, so they will better understand the problems their students face. The pre-service teacher should experience the risk-taking involved in problem-solving learning by engaging in open-ended, self-paced investigations of some major ideas and theories within his special field. Also, the pre-service teacher should have experience in teaming up with pre-service teachers in variousfields to work on certain problems. Insofar as possible, the entire teacher education program should be unified, tying together courses in the school of education with those in other departments and schools. This kind of unification could itself be developed by a team consisting, for instance, of an educational or developmental psychologist, curriculum specialists, and representatives of several disciplines.

Student teaching should start early, perhaps in the freshman year, partly for earlier contact with the realities of teaching and partly to avoid the loss of interest that may lead some to leave the program. A broader, less specialized education for the prospective teacher should better prepare him for teaching, and help test whether a liberal education does, in fact, help prepare one to deal with reality.

In-Service Education and Resource Centers

Whether as refreshers for teachers using problem-solving activities or as an introduction for teachers who are not, universities should develop formal programs, special courses, mini-courses, or seminars in problem-solving for in-service teachers. These could be attended by individual teachers, or by groups of teachers jointly teaching problem solving in some school, who wish to make significant use of problem solving in their teaching.

Regional resource centers will be needed to maintain collections of teaching materials; to compile extensive teaching guides cross-indexed to various files; to provide laboratories and shops for working in wood and metal designing equipment and creating visual aids; to gather information about available resources; and the like. A resource center could serve a school, group of schools, district, county, or state. It should be built into the formal structure of the schools it serves, and have a permanent staff to assist teachers and to coordinate problem-solving activities.

Development and Implementation

In the past, the development of new educational programs has usually been separated from the processes for implementing them. In this report the model of curriculum development is viewed as also constituting the model for its implementation. The problem to be solved by problem-solving education is that of installing and operating problem-solving education. Initiation and development of problem solving in a school can proceed best if it is accompanied or preceded by the suggested changes in teacher education and development, and by the dissemination of materials through resource centers.

A knowledge of some of the literature about the effectuation of institutional and social change might be useful for some of the persons involved. In the long run, the ability to bring about change in the relevant college

faculties may be critical. In the short run, attitudes of teachers and support by school boards and administrators will be key factors.

While the model itself is simple, carrying it out effectively will be difficult, since a variety of resources and types of expertise, coordinated across the entire nation, will be needed. In due time, the model should be tested across many geographical and cultural segments of the population, and at various age levels. Because relevant programs and interested groups already exist in many places, both local and national, programs have a preexisting base on which to build coordination.

A national advisory board for comprehensive problem-solving-based education should be established promptly. It should, among other things, organize a consortium of problem-solving-based curriculum projects. Such a consortium would include: 1) national clearinghouses for materials and information 2) curriculum development groups; 3) colleges using a problem-solving approach; 4) teacher certification units of state departments of education; 5) regional resource centers; 6) schools involved in pilot programs; and 7) evaluation groups. The advisory board would initiate and correlate programs, review programs, and assist in the search for funds.

New or existing curriculum development groups could identify particularly suitable and workable kinds of problems, with illustrations of the materials and techniques appropriate for each. They could also arrange for "brainstorming" sessions with teachers, students, and other relevant professionals to assist teachers in knowing how to guide students in solving their problems. Such groups can study the equipment needs for various numbers of students working on various kinds of problems, as well as studying the most feasible layout of laboratories, shops, and resource centers. School resource centers could become repositories of information developed by students as they deal with problems, so that subsequent students need not retread the same paths. Students might thus develop their own "scientific" literature.

With the help of the consortium, a pilot study should be tried soon in a full school system wherein the learning environment proposed can be tested. Its actual inauguration would be preceded by talks and conferences involving students, teachers, administrators, parents, and the community at large. For this, as well as for subsequent programs, evaluation will need to be designed to determine the effectiveness of the whole problem-solving approach. Also, one should question whether certain community participation techniques that seem to work successfully with limited groups of students over relatively short periods will also work with greatly increased numbers of students on a long-term basis. The evaluation should also focus on the suitability of various techniques in assessing the accomplishments of students. Because community cooperation is so important to the continuing success of such education, particular attention should be paid to community attitudes generated by the program

References for the Overview

(1) Ackoff, Russell L., "Systems, Organizations, and Interdisciplinary Research," General Systems, V, 1960.

RECOMMENDATIONS AND SUGGESTIONS FOR ACTION BY SCHOOL AND COMMUNITY GROUPS

It is the strong hope of the conferees that the conference will initiate rapid progress towards a curriculum based on comprehensive problem solving in secondary schools. For that reason, this section is directed to all those groups that are in a position to act on these issues or to instigate action. Recommendations have been made under various topics for long- and short-range goals and actions and are reiterated here in relation with the people or organizations that can carry them out.

Students and Parents

The people most affected by the educational system are the students, followed closely by the parents through their concern about their children's futures. Governmental and educational establishments are usually responsive in some degree to the expressed desires of the population being served. Thus an informed interest in a comprehensive problem-solving program among students and parents can bring such programs to the attention of their school systems and can support teachers and administrators trying to initiate them.

It is recommended that a significant portion of the secondary school curriculum be allocated to a problem-solving approach that allows students to deal with and act on real problems, both in the school and the community.

It is hoped that students and teachers will seek out information and provide opportunities for debate of the issues involved in implementing such a program. Various reports and books have been cited, and more could be collected in a bibliography. Perhaps these could be circulated through town libraries or by parents' organizations.

Parents can ask to have the adoption of a curriculum based on comprehensive problem solving debated at school committee meetings or can introduce the topic at regional or local parent meetings. In due course, public meetings can be held, sponsored by the school board or groups of parents and with guest speakers who have experience in problem-solving programs. The views of students as to the role of education in their lives should be well represented at these meetings.

If the result of these discussions is the recommendation that school administrators foster comprehensive problem-solving activities, students and parents can then still have an important long-term role. Citizen committees can help to establish between school and community the links that will facilitate the students' problem-solving activities. They can work jointly with teachers and administrators in recommending legislative changes necessitated by the new educational format.

Inner-City Groups

Consideration by all students and parents, regardless of where they live, is a part of the general public debate advocated in the previous section. Special issues need to be raised, however, with respect to the needs and priorities of students in the inner-city.

It is recommended that a broadened curriculum be developed that supports teachers in identifying local problem situations, provides them with intellectual

support and suggestive models and examples, and describes processes whereby students can be an integral part of defining the learning process.

The conferees believe that a comprehensive problem-solving-centered education is of general applicability. It can benefit students with different backgrounds, interests, and aspirations, since it is based on problems that have meaning for them. More than that, it can be surmised that the integrating and open nature of problem-solving activities provides transition points and mobility to help open up new opportunities for students.

Only those people directly affected can properly evaluate these assertions. We urge their full consideration of the points at issue and early trials of comprehensive problem-solving programs in schools that serve inner-city communities.

Curriculum Development and Dissemination Groups

Simultaneously with public discussion of the issues, those curriculum organizations that have a present interest in extending problem-solving education must establish a national collaboration. Without this, even the public debate will be inhibited by inaccessibility of information, and by lack of channels for obtaining supporting materials. In addition, communities will want to know the degree to which their curricular experiments correlate with others across the country.

It is recommended that a national advisory board for comprehensive problem-solving education be set up on a continuing basis as soon as possible, and that this board organize a consortium of problem-solving-based curriculum projects.

We urge that a series of short meetings be held among representatives of the various groups that would initiate a national consortium along the lines discussed previously. These meetings can begin to take place during national meetings of education organizations, such as NCTM and NSTA. As soon as possible, a proposal should be made for the support of a national advisory board. The board can then continue to broaden the base of a national consortium of curriculum projects.

In the meantime, each interested curriculum development group, clearinghouse, or other education group can begin to reformulate its own program to support problem-solving activities and provide materials for teachers and school systems. In many cases, their present budget and mandate permit an immediate shift in this direction. Budget requests for fiscal 1974 can make explicit allowance for such activities.

College Faculties and Administrations

Colleges and their staffs can be a critical factor in the formation of the national consortium. Many of the country's school and college curriculum development, clearinghouse, and evaluation groups are housed in and staffed by institutes of higher learning. The efforts of individuals and the policies of the institutions can both be brought to bear on the planning and creation of the consortium.

It is recommended that the entire teacher-education program be unified, including courses taken in other departments and schools, as well as those taken in the school of education.

In addition, colleges can provide a range of courses that would support the emergence of a comprehensive problem-solving program in a variety of ways. Even one problem-based interdisciplinary course would enable undergraduates to consider the value of such activities for school education. In in-service courses and seminars, content could be geared to provide interested local school teachers with information about the content and techniques of comprehensive problem-solving activities.

College graduate courses or research could poll students to determine their interest in specific problems or the general approach, suggest problems, and formulate procedures for introducing them to secondary school students, evaluate ongoing comprehensive problem-solving activities, and prepare and apply evaluation instruments suitable for comprehensive problem-solving programs.

It is recommended that colleges and universities solicit support for their new programs from both the school system and the community.

These institutions can also provide occasions for public discussion of problem-solving programs. Open seminars can be sponsored. In-house media or press releases can be used. Special seminars may be offered to school administrators or other groups that have to deal with the implementation aspects.

Secondary School Teachers and Unions

In many ways, the secondary school teachers are at the critical juncture to initiate comprehensive problem-solving programs. They can raise the issues with their students to obtain their interest. They can challenge their students to take on a problem within the available schedule; or they can go further and obtain the collaboration of other teachers and the principal for changes in the school format. At meetings of parents or elsewhere, the problem-solving idea can be introduced and explained by teachers.

Reporting such activities to national societies, curriculum groups, and clearinghouses is recommended as one of the best methods of developing interest and support. At the early stages, the extent of this reporting will be an important indication of wide acceptance of the program within schools.

It is recommended that teachers, with the aid of the school administration, be given a role in the institutional decision-making process, have access to resources outside the school, and the administrative flexibility to make necessary arrangements for students to engage in problem-solving activities in the school and in the community.

Teachers and their union officials can instigate many of the organizational changes needed to support a comprehensive problem-solving program. The addition of teacher resource centers in school can be requested to facilite team planning and communication with outside resources. Teachers and union officials can recommend the use of facilities for student resource rooms. Perhaps most important from the union standpoint is to consider the redefinition of roles of teachers. Recognition must be obtained for coordinating student projects and for interdisciplinary activities. Responsibility for specific content must be relaxed in favor of the fostering of more general learning experiences. Curriculum-development activities by teachers should have union support.

School Administrators and School Boards

As interfaces between community and teachers as well as planners of the school programs, school board members and administrators have several key roles in developing a comprehensive problem-solving program. They can provide opportunities to discuss such programs among their staffs or in the community. They can suggest trial programs and help make the arrangements to support such trials. It will be primarily their responsibility to plan the more ambitious, longer-range modifications of their schools towards a problem-solving program.

It is recommended that when it becomes evident that new secondary school space is needed, school boards and administrators should consider spaces in a variety of locations rather than the current campus centralization, and school cars and minibuses to complement public transportation.

In implementing significant changes, school boards and administrators will be working with students, teachers, citizens, and legislators to formulate role changes and modifications of facilities. They will have primary responsibility for collaborations among the community, staff, and students.

It is recommended that an assessment program be developed that takes into account those skills, attitudes, concepts, and principles that characterize the intellectual legacy from previous generations, as well as the capability to solve current problems and take appropriate action.

It was suggested at the conference that it will be an important task of the administrator to provide a reward structure that encourages comprehensive problem-solving activities. For a reward structure to be effective, the administrator must be kept informed of the relevant activities in the classroom. The effectiveness of a teacher in supporting a discipline can be measured by specific performance tests of the students, but this approach will be less adequate for problem solving. Simply by requesting reports on problem-solving activities, an administrator is letting the staff know that such activities are valued. The value of the program must be built into review, promotion, and salary policies.

Boards of Certification and Accreditation

New organizational formats, staff roles, and education requirements may be planned and agreed to by community citizens, school administrators, and teachers, but implementation may be impeded by existing rules at the state or national level. The most appropriate education for teachers in comprehensive problem-solving programs may not be consistent with certification requirements designed for specialists. Accreditation of schools may depend on disciplinary formats and requirements no longer relevant. Other curricula, space, and staff requirements sometimes imposed by state boards may not allow optimum economical use in the new type of program.

It is recommended that in the framework of a unified education program, early experience in the classroom be provided, a teacher have a specialty that is selected from a wide list of contemporary fields, and there be a component that deals with self-analysis and awareness.

Boards of certification and accreditation can give early consideration to the changes that a comprehensive problem-solving program may require. This would enable an early response to queries from school systems. Furthermore, it would help ensure that changes were carefully considered, and with appropriate safeguards. A notice of changes being made or considered may encourage communities that would like to try a problem-solving program but are concerned about potential conflict with existing rules.

Legislators and Government Executives

We encourage legislators to have early hearings on the nature of the suggested program and of public sentiment towards it. Although comprehensive problem-solving programs are not especially high-cost programs, they will clearly be competing for funding with other educational development and implementation programs. Some of these other programs will be antithetical in nature to the one recommended by this report. It will ultimately be up to the legislators and the executive branch of the government to decide on priorities for federal agencies and funds.

We believe that this conference's recommendations represent a significant departure from the usual style of this country's education and may have important beneficial effects for all of society. Consequently we hope that it will receive a major share of attention from those responsible for national policy.

APPENDIX

TOPICS FOR A COMPREHENSIVE PROBLEM-SOLVING BASED CURRICULUM

In comprehensive problem-solving emphasis is placed on investigatory activities related to finding solutions to problems identified by and real to the students. Some examples of possible topics for a comprehensive problem-solving based curriculum are included here to illustrate the diversity and range of possible involvement by students in a problem that students would study with the support of teachers with diverse subject matter backgrounds. The intention is not to imply that the ideas inherent in these examples are original or that there is a need to launch a major new curriculum development effort to produce new and original materials for adoption in schools. Over the past decade numerous groups and individuals have expressed their concern by either recommending or developing novel and imaginative approaches to modifying the secondary school curriculum. Much of the work that has been done is in harmony with the ideas in this report. It is impossible at this point in time to present a full curriculum of comprehensive problem-solving topics, but the examples should give some indication of the possible range.

A central concern of the conference has been with styles of teaching and attitudes of administrators, teachers, and parents involved in educational experiences that are most likely to be of long-term benefit to students. The emphasis has been more on the style of the curriculum and less on its specific content. For this reason, there is less need seen for the specific development of new materials, but more emphasis on communication concerning experiences with extant materials and their actual or possible effect on the school environment. All examples do not necessarily have all the features of ideal comprehensive problem-solving materials as discussed in Chapter 2, but they were prepared to exemplify the style of activities and the approach under consideration.

It is our position that ultimately the development of curriculum ideas will most profitably take place within the schools themselves. We need, however, to get a sufficient number of teachers started and to provide on-site support and a vehicle for disseminating their experiences. The particular examples presented might arise as real problems for <u>some</u> students and should be considered by teachers and others only in that context, but it is hoped that the style and approach will be utilized.

Some students who originally get involved in any of the suggested activities will likely lose interest in a short time; others will want to follow the activities (or branches of them) into considerable depth. This will depend on many factors. Chief among them are:

1. background of the student;
2. student interest in the problem being studied;
3. teacher interest in the problem being studied; and
4. other demands on the student for time and energy.

Sample Topic #1: GETTING THE MOST FOR YOUR MONEY

The adolescent is appealed to through advertising, and has a desire by

inclination and need, to spend money for valued goods and services. These goods and services range from skiing to movies and from pencils to automobiles. "Getting the Most for Your Money" can be broken down into subproblems such as, earning money (allowance, job, investment, gifts), spending money for goods or services, having or possessing money (saving and holding), attitudes toward money, and alternatives to money as an economic resource.

Considering just the problem of spending money for goods and services, there is a possible sequence of activities that could begin with a presentation to the total student group, after the problem has been raised by one or more students, of a collage of goods and services (picture representations), radio or television commercials generated by students, reports on the activities of Ralph Nader, or transparencies of advertisements. There could also be a bulletin board with advertisements directed to teenagers. Key questions such as, "Who has enough money for everything he wants?" "What would you like to bu Need to buy?" (sports equipment, clothes, food, audio-equipment, hobby "stuff, entertainment, a used car, and so on) could then be discussed in small groups of three to five students to determine what goods or services, if any, they are interested in and why. There could then be feedback to the total group and the formation of task groups of three to five students clustered by interest in similar goods or services. There may be many task groups depending on the variety of goods and services the students have identified.

One task group might decide to work on the process of approaching and attacking the problem, "How should someone move toward the decision to buy a used car?" They could begin by examining sources of reliable information about used cars using general ones such as consumer reports, Better Business Bureau, friends, or Yellow Pages, and ones specific for a used car such as the Blue Book, mechanics, diagnostic centers, auto magazines, Nader's reports, newspaper advertisements, bulletin board advertisements, Owners' Manuals, amateur experts or television commercials. The relative reliability of each source of information would need to be investigated and discussed.

At some point they would probably wish to investigate ancillary informatio involved in trade-offs such as, financing, depreciation, operating expenses, safety features, insurance, personal ability to make small repairs, ability of parents to help in maintenance, immediate and potential future need for a car, design, appearance (inside and outside), pollution emission, accessories versus gas consumption, and the time required to study the problem.

Each task group would be responsible for deciding the amount of time it wi spend on the problem, as well as what modes and organization it will use for gathering data, providing feedback, making decisions, and determining the prod the group will provide. For instance, some products might be a buyer's guide to used cars; a radio program; television commercials; search, purchase, and evaluation of a used car; or an article in the school newspaper.

Some of the possible outcomes from a study of the problems connected with the purchase of a used car might include:

Communications

1. How to write letters to obtain information on a product
2. How to obtain information from newspapers and determine how trustworthy the information is

Science

1. How to detect air pollutants such as sulfur, lead and carbon monoxide
2. How to compare stopping distances of radial and standard tires
3. How alcohol and other drugs affect reaction times
4. How lubricants differ
5. How studies are done for Consumer Reports
6. How to determine mechanical to electrical energy conversions and the reverse
7. How to determine the efficiency of an internal combustion engine

Social Science

1. How insurance rates are determined under various situations
2. How much interest on a loan adds to the cost of a car
3. How to compare Blue Book price with that actually charged by dealers
4. How to determine cost in time and money to shop around to different dealers and to try out different cars
5. How to determine liability of owner, insurance company, and bank if a car worth $1100 is a total wreck while the owner still owes $1500
6. How to determine relative importance of the condition of the motor, clutch, body, transmission, and tires on a used car
7. How to determine relative importance of aspects of design and comfort
8. How responsible an owner is for conditions of a car that could injure others

Entirely different problems and activities arise when students choose any one of the other subproblems. For instance, when investigating alternatives to money as an economic resource, students could get involved in investigating the use and misuse of charge cards, use of computers in keeping track of an individual's transactions in the monetary world, how people react psychologically to having their monetary records stored in a computer, how money developed and the types of money, the advantages of a money economy, advantages and disadvantages of barter, functions of money, how to determine the value of money, and what is the difference in cost of an item charged in comparison to its cost in cash. Students might wish to consult with bankers and computer experts, as well as read books such as The Cashless Society by Robert Hendrickson.

Sample Topic #2: SILVER BAY

Silver Bay is a small town (population 3000-4000) on Lake Superior. The town is the site of a preprocessing plant for enriching low-grade taconite ore before shipment to steel mills. The only industry in town is Reserve Mining, which dumps 160,000 (?) tons of taconite tailings into the lake everyday.

These tailings are impacting the ecosystem in the lake. State authorities have proposed modifications to decrease environmental impact. These are opposed

by Reserve Mining, which threatens to close its plant and thereby wreck the town's economy. Duluth, the nearest city, already has high unemployment and cannot absorb the additional workers.

Another problem is the empty pits left by the strip-mining of the ore. Some pits have been converted into lakes, but the acidity of lower strata eventually kills aquatic life and plantings and gets into ground water.

The following are a few of the questions and discussion topics that might arise from "Silver Bay" or a similar situation organized by subject area.

Social Studies

1. Economics of the situation
2. What is social value and <u>total</u> social cost of mining low-grade ore?
3. Disruption of lives of many inhabitants
4. Interviews with local residents
5. Locations of raw materials for steel in relation to plants
6. Analysis of arguments set forth by labor, environmentalists, management, and town governments

Biology

1. Ecology of Lake Superior and impact of tailings
2. Ecology of open-pit "lakes"
3. Effects of strip-mining on the ecosystem

Chemistry

1. Process for separating iron from taconite
2. Processes involved in making steel

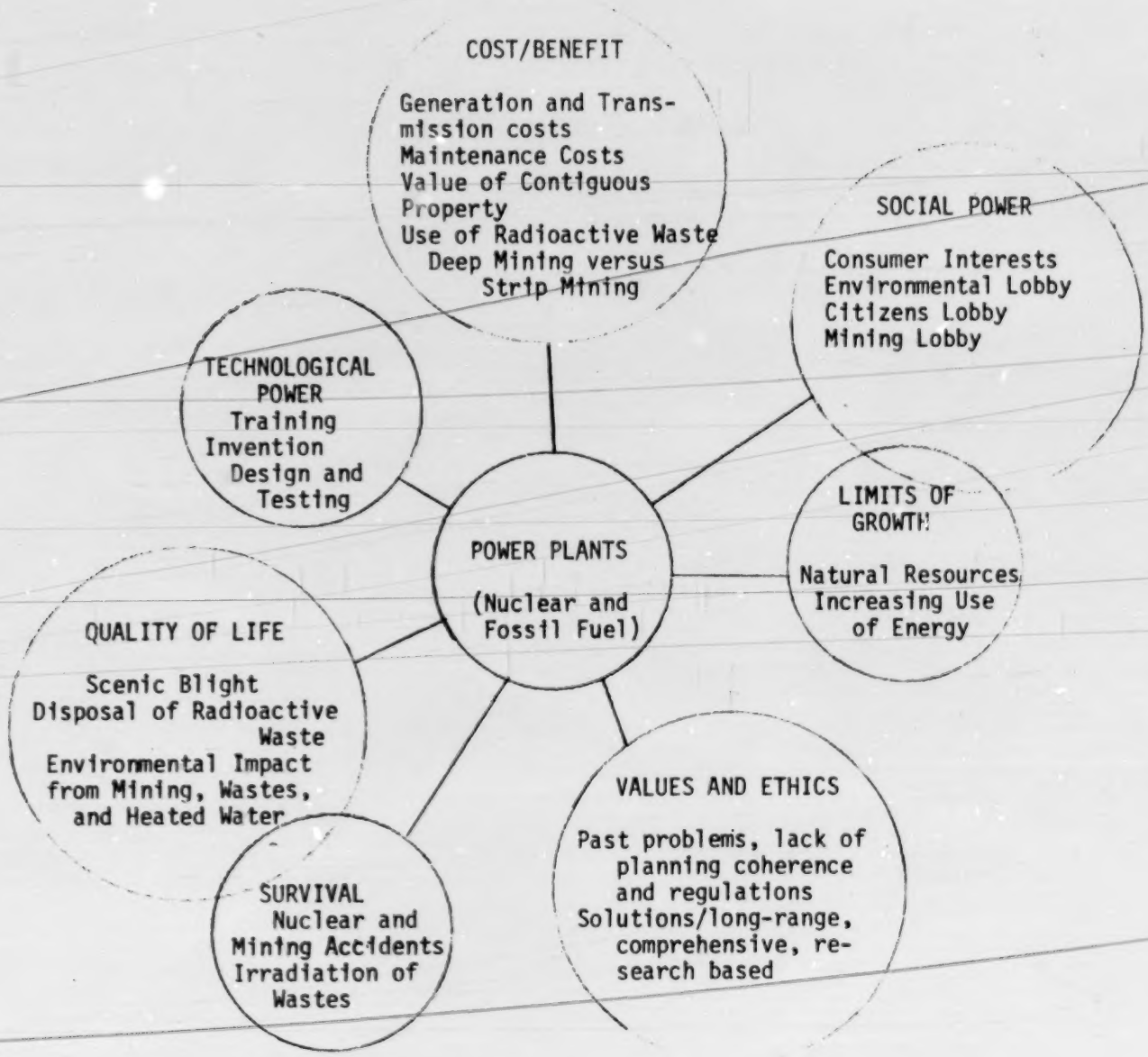
Earth Science

1. Geology of region
2. Locations of similar ore deposits
3. Locations of coal and limestone that are also needed to make steel

Industrial Processes

1. For making coke, iron, and steel
2. What are the polluting aspects of each
3. Mining, transporting, and processing ore; conveyor belts, ore ladders, and so on

Off-shore nuclear plants is yet another problem. It has been proposed that future nuclear power plants be located on off-shore platforms. This has the advantages of isolation from communities that fear radiation hazards, and availability of large quantities of water for cooling. Some of the issues involved in the production of power are suggested in the following diagram.


COST/BENEFIT
Generation and Transmission costs
Maintenance Costs
Value of Contiguous Property
Use of Radioactive Waste
Deep Mining versus Strip Mining
SOCIAL POWER
Consumer Interests
Environmental Lobby
Citizens Lobby
Mining Lobby
TECHNOLOGICAL POWER
Training
Invention
Design and Testing
POWER PLANTS
(Nuclear and Fossil Fuel)
LIMITS OF GROWTH
Natural Resources
Increasing Use of Energy
QUALITY OF LIFE
Scenic Blight
Disposal of Radioactive Waste
Environmental Impact from Mining, Wastes, and Heated Water
VALUES AND ETHICS
Past problems, lack of planning coherence and regulations
Solutions/long-range, comprehensive, research based
SURVIVAL
Nuclear and Mining Accidents
Irradiation of Wastes

Possible questions and discussion topics on this problem might be:

Physics

1. Generation and transmission of electricity
2. Hydrostatics
3. Nuclear physics
4. Thermodynamic ideas
5. Possibility of runaway
6. Reactor physics, including control
7. Nuclear accident and irradiation of water

Social Studies

1. Economics of large distance power transmission, cost of platforms, and so on
2. Property values in the vicinity of the platforms
3. Social aspects of large amounts of radioactive waste
4. Analysis of present and planned disposal and storage of radioactiv waste
5. Use of some radioactive wastes in medicine and other areas

Biology

1. Biological effects of radiation exposure
2. Environmental impact of heat in cooling water and air
3. Environmental impact of radioactive wastes

Chemistry

1. Separation of isotopes
2. Separation of uranium from ore
3. Radioactivity and half-life
4. Characteristics of elements

Mathematics

1. Calculation using half-life

Language

1. Read and comprehend related literature
2. Write reports

Aesthetics

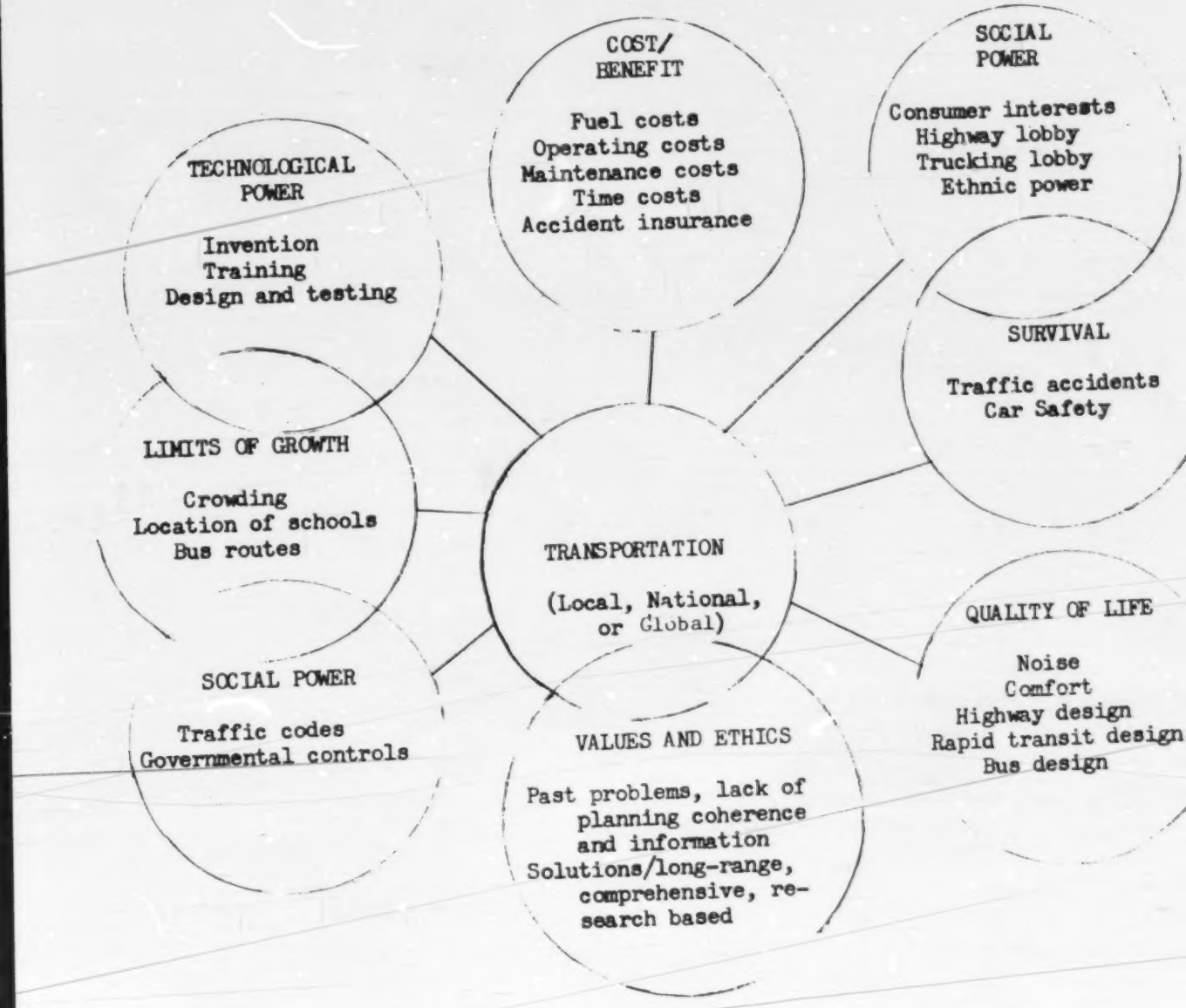
1. Effect of offshore platforms on weekend visitors who go to the seashore for reflection and relaxation

Sample Topic # 3: TRANSPORTATION

The general area of transportation encompasses a significant number of problems such as:

1. Getting to and from school
2. Getting to and from recreational areas or facilities
3. Meeting family transportation needs
4. Delivering commodities to families
5. Meeting transportation needs to areas outside local community

Each problem suggests many subproblems that can be organized using some of the issues explicated in Figure 2 in Chapter 2. Some of these subproblems and issues are shown in the following diagram.



The problem "Getting to and from School" will be considered further, since it is a problem not only for students in large cities, but one that is also much evidenced in rural areas where regional community schools are in existence, and in medium sized cities as well. Recent social development, such as busing to achieve racial integration, have added new dimensions to the problem.

The problem might be raised by students as a result of a bus or pedestrian accident. It could also be initiated by asking questions such as, "Do any of you have a problem getting to or from school? If so, what and why?" or, "How much of the day is spent getting to and from school?" An appropriate film might also start students discussing their problems.

In order to continue, the topic might be reformed into a specific problem. For example, "What is the best way for students in our class to get to and from school?" A discussion of the meaning of this problem might center on the meanin of "best way." Possible answers might include: easiest, shortest, fastest, mos pleasant, least polluting, safest, most economical, and so on. If problems are identified, then a question that might be raised is, "What can be done about the ways of getting to school so that they might be improved?"

One way to proceed in the investigation and solution of a problem is to identify the perceived aspects. Two aspects, modes of transporting students to and from school and travel factors involved in the process are shown in the matr that follows. Students working on the problem will probably think of other travel factors and modes of transportation, as well as other aspects to be considered.

PERCEIVED ASPECTS OF PROBLEM

MODES OF TRAVEL

TRAVEL FACTORS	School Bus	Public Transp.	Personal Car	Bicycles	Walking	Hitch-hiking	Other
Time							
Schedules							
Safety							
Comfort							
Costs							
Rules and Regulations							
Traffic Patterns							
Attitudes							
Condition of Vehicles							
Condition of Routes							
Competition with Family Needs							

In order to evaluate the travel factors selected for examination data will need to be collected, some related to school buses might be the

1. waiting time for buses at pick-up points
2. time spent on buses
3. accidents that have occurred
4. seating arrangements on buses
5. insurance coverage
6. state laws relative to school buses
7. bus routes
8. traffic flow and density
9. attitudes of students toward busing
10. frequency buses are serviced

Some problems students might choose to investigate relative to school buses could be:

1. Are pick-up sites adequately located?
2. Is the school well located to serve the student population and to lessen time involved in travel to and from school?
3. Can the amount of time spent on bus travel be shortened?
4. Should the rules and regulations governing students riding on buses be modified?
5. Are the state laws being observed in the operation of the buses?
6. Is there adequate room for loading, unloading, and parking of buses?
7. Does the operating condition of the bus affect getting students to and from school?

The problems selected for investigation and the data collected will vary with the modes of travel and the travel factors involved, and the possibilities are quite extensive.

Sample Topic # 4: MIGRATION

In a very provocative book, A Nation of Strangers, Vance Packard, one of our nation's eminent sociologists, deals with an urgent problem - the fragmentation of our society resulting from our transient nature of existence. The author points out that about 40 million Americans change their home addresses at least once each year. This means that at least a fifth of all Americans move one or more times each year, and the pace of this movement of Americans is increasing.

As a result of these movements great numbers of American feel unconnected to either people or places, and throughout much of the nation there is a breakdoes in community living. Packard points out, loosely rooted people pursue a curious life-style with little concern for the social consequences of negative behavior.

Perhaps the worst effect of this massive uprooting is its impact on children. They are apt to grow up without a sense of community, with many personality disorders growing out of instability, and with a sense of strangeness and a legacy of coldness to others.

A specific problem that could arise is, "What can high school students and teachers do to help newcomers develop a sense of community in their new environment?" The problem can be quite real, because by junior and senior high school "cliques" have formed and are a big factor in establishing social relations. New students often find themselves not being accepted by an established group of young people. Hence, newcomers are isolated and become miserable. The ninth grader is especially prone to such action.

The realization of the existence of this real-life problem, and the desire to do something about it, to seek a solution for it in one's immediate school environment, may come about in several ways.

First, of course, students need to be made aware of the problem - if it exists - and to be motivated into finding a solution. The most obvious and direct approach to the problem would be to poll the class at the beginning of the academic year, or soon thereafter, in order to discover who the newcomers to the community are. This may be complicated by the fact that often at the 7th or 9th grade level, all students may be "newcomers" to a particular school, coming from various elementary or junior high schools as the case may be. However, the students who are not newcomers to the community at large (the neighborhood in the case of a large city, or the entire town or city if it is smaller) will know others in the class who came from the same elementary or junior high school as they did.

Having found out how many newcomers to the local community there are, perhaps the class might discuss what problems newcomers face. Often these are of four kinds:

1. Not knowing others who share one's concerns
2. Not knowing others one can depend upon in a pinch
3. Not having one or more really close friends
4. Not knowing others who respect one's competence

Having identified these needs of individuals, the class might design and complete a questionaire based on them with questions such as:

1. Approximately how many students in your class (or in the 7th or 9th grade in this school) share the same interest as you?
2. Do you feel that most other students in your class are strangers?
3. Are you a member of any organization in the school?
4. Do you know a fellow student who would feel personally concerned if you became seriously ill?
5. If you had a need for a lift, how many people in your class would you feel free to call and ask for a lift?
6. Have you socialized in the evening with any person in your class?

Questions of these types may give insights into the feelings of both newcomers and those who have not recently moved into the community. Students will undoubtedly enjoy thinking of other similar questions for their own questionnaire. That is, questions that will seek evidence as to whether students know others who share their concerns, whom they can depend upon in a pinch, who are really close friends, and who respect their competencies.

It is anticipated that when the answers to such a questionnaire are compiled it will readily be seen that a problem exists. The questionnaires might ask the respondents to indicate whether or not they are newcomers to the community. Then the answers can be divided into those who are, and those who are not, and the results compared and contrasted. Tables can be developed to show the results. Some low level statistical analyses may be made.

Out of such activities the class might decide that a problem exists, and that some action must be taken to help build a sense of community within the school.

There are many aspects to the migration problem that can come up as the students consider ways and means of developing a better feeling of community, or integrating newcomers into this community, of helping newcomers and those who are not new to become less lonely. Some of these might be:

1. Why do so many people in America move?

   In order to deal adequately with individual problems resulting from being uprooted and resettled in a new community, students need to understand reasons for the large scale migrations that are a part of our society. They might develop a chart indicating the reasons why families represented by students in their classes have moved. Among these might appear:

   a. Ecological reasons, or natural causes - floods, tornadoes and hurricanes, earthquakes, long pronounced dry seasons
   b. Political reasons - forced migrations due to governmental pressures, or due to urban renewal, highway development
   c. Organizational reasons - where large companies transfer workers or managers from one part of the country to another, or where the military might transfer personnel from one place to another
   d. Job opportunities - where workers might quit one job to take another in a different locality and hence move to the place of the new position
   e. Social reasons - where people becuase of prejudice or desire to improve the way of life, move from old neighborhoods to new ones, such as a move from inner city to suburb

   The class may develop other reasons that do not fall into the above categories.

2. Where did the newcomers originate?

   The students may decide to show the place of origin of the newcomers on a map. Discussion might evolve around varying distances involved in the moves. Perhaps a pattern can be discovered, and a theoretical statement developed about migration and distances.

   Newcomers might be asked to talk about their former communities, telling how they are similar to or different from their new localities.

3. What are the characteristics of the newcomers?

   Care must be exercised in order to deal with this question. But it might be important in the development of a solution to know some of the physical, economic, social, and political characteristics of newcomers to a particular school. Individuals at this point need not be identified.

4. Where do newcomers in the community live?

   Here again, a map might be made. The map might contain the residences of all students, indicating by a different color those who are newcomers. Is there a pattern?

5. What does the community do for newcomers?

   This will call for an investigation of what is being done for families outside of the school itself. Groups of students may go to talk to the Chamber of Commerce, to religious leaders in the community, to social welfare agencies, and so on.

6. What does the school do for newcomers?

   The principal might discuss what happens when a new student enters the school - the need to obtain past records, the establishment of new files, and so on. Other faculty members, such as school counsellors, might also be interviewed.

   Out of this investigation should come a list of services now being offered, and a list of omissions. Again, the class might compile a list of things a school can do to help new students adjust to their new environments.

7. Consideration of alternative solutions and possible actions. The students might wish to consider a number of alternative solutions to the problem of helping students develop a sense of community in their new environment. At one extreme, it might be concluded that nothing much can be done - only time will take care of the problem. Others may feel that the solution must take place outside, and therefore suggest ways and means of reshaping or developing community services to newcomers.

The importance of the problem proposed should not be denied, or minimized. One can adjust to a rootless style of life, but a society cannot permit its members to be rootless. That will result in a decline in satisfying group activities, in mutual trust, and in psychological security. Personal relationships become shallow in a rootless society, and one develops an indifference to community problems. One's behavior is profoundly affected in many antisocial ways. Schools need to help young people overcome the results of high mobility in our society. Surely this is a "hands on" type of social problem with which young people can and must deal in their own ways.

A completely different issue that might have relevance to adolescents is "Where do you want to live and work as an adult?" This might grow out of this sample topic or might be initiated independently. There can be many avenues of qualitative and quantitative research involved, for instance labor markets, recreational facilities, and cost of living and housing in various areas of the country.